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METHODS OF FIELD DATA ACQUISITION, REDUCTION AND ANALYSIS FOR GROUND ELECTRONIC EQUIPMENT RELIABILITY MEASUREMENT

(An Interim Engineering Report)

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New York

ABSTRACT

This report describes the methods of acquisition, processing and analysis of field data for reliability measurement on three classes of Air Force Ground Electronic Equipments. The field study was designed to acquire sufficient controlled data for comparison with theoretical reliability predictions and laboratory tests that have been concurrently performed on the same equipments. The equipments observed are as follows:

Radar	(AN/FPS-3),
Navigation	(AN/GPX-20) and
Communications	(AN/GRC-27).

A sample of equipments of each type above was selected for observation from four operational squadrons within the Central Air Defense Force. The program at each site consisted of the following elements, described in detail in the report:

(1) Indoctrination of Radar and Communications Personnel;

(2) Collection of general information about the site, including equipment, operation and maintenance procedures;

(3) Measurement of equipment environment; and

(4) Establishment of controlled data collection.

The controlled data collection phase has extended over a period of about one year.

Data processing, statistical and engineering analysis techniques are described. To illustrate the variety of information available and the methods of access, a sample machine run-off tabulation for the FPS-3 is presented. This report describes methods employed; results on all equipments and sites will be contained in the forthcoming Final Engineering Report.

ACKNOWLEDGEMENT

The Commander, Rome Air Development Center, wishes to thank the personnel of Central Air Defense Force operating squadrons for their cooperation and assistance on the Reliability Prediction and Measurement study recently completed. The interest and support of squadron commanders, communication and radar officers, site engineers, and maintenance personnel, has assured the success of this program.

15 May 1958

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METHODS OF FIELD DATA ACQUISITION, REDUCTION AND ANALISIS FOR GROUND ELECTRONIC EQUIPMENT RELIABILITY MEASUREMENT

1. INTRODUCTION

1.1 Purpose of the Report - The purpose of this Interim Engineering Report is to describe the methods used to acquire, reduce and analyse data obtained from ground electronic equipment located at four Air Force installations in the Central Air Defense Force (CADF). Information from three major categories of ground electronic equipment was collected. The three specific equipments selected for this program were:

a. Radar - AN/FPS-3
b. Navigational Aid - AN/GPX-20
c. Communications - AN/GRC-27

Failure data plus environmental, maintenance and other pertinent information has been collected over a period of one year and will be used to verify theoretical reliability predictions on the above equipment. Individual predictions on each equipment are contained in special engineering reports here referenced.[1, 2, 3]

1.2 Overall Program Goal - Before describing the field data collection phase in detail it will be well to consider the principal goal of the measurement and prediction study. It may be stated as follows:

"To develop and validate a method for prediction of reliability of ground electronic equipment in advance of production."

To accomplish this stated objective, a three phase program has been in progress: (1) Prediction of inherent reliability, (2) Laboratory test to verify the prediction, (3) Field measurement to substantiate the prediction and laboratory tests. Due to the great variety of environmental conditions, maintenance practices, equipment usage and history, etc., it is not expected that field measurements of reliability will be numerically equal to prediction or laboratory test results. However, the relationship or correlation between these phases and the effects of the dominant environmental factors must be determined if the maximum value is to be gained from a prediction.

1.3 Objective of the Field Data Collection Phase - To acquire a sufficient quantity and quality of field information to enable valid comparison with prediction and laboratory test results was the objective of the field data collection phase described in this report. Data on equipment performance, failures, maintenance practices, training and experience of personnel, environmental factors, and others were essential requirements of the field program. The organization and implementation of the program are described in the following sections.

2. ESTABLISHMENT OF THE FIELD DATA COLLECTION PROGRAM

2.1 Selection of Equipment - It was initially intended to select equipment in each of the three major categories which represented the latest produced items. However, it was found that such equipment was not in the field in sufficient quantities to provide adequate failure data and conveniently located to make it economically feasible. The AN/FPS-3, AN/GPX-20, and AN/GRC-27 appeared to be the most logical choice. They are used extensively in the field as a system and have been in operation for a sufficient time to have accumulated quantities of data. Other advantages of selecting mature as opposed to newly introduced equipment are: (1) the learning curve, that has a pronounced effect on reliability of newly introduced equipments, will not be a large factor for the mature equipments, (2) engineering changes and retrofits that generally plague data collection programs on new equipments will not be a major factor on mature equipments.

2.2 Equipment Locations - The three equipments studied are used by Aircraft Control and Warning (AC&W) Stations operated by the Air Force, strategically located throughout the United States and overseas. Although it is generally recognized that environmental extremes adversely affect equipment performance, this study was not designed to determine the effects of world-wide environmental conditions on reliability. The emphasis was placed on obtaining controlled, high quality data from a more limited source. Four AC&W sites within the Central Air Defense Force (CADF) were selected. The locations represent a moderate variation in climatic conditions; equipment usage was similar at each site.

2.3 Planning for Data Collection - All too frequently in the history of data analysis the complaint is raised that vital information is missing. In nearly every industrial organization there are files of data which will never be analyzed due to incomplete information. The analyst all too often is called in after the data has been collected and requested to come up with clear, valid and undisputed conclusions. In a serious attempt to avoid this after-the-fact dilemma, the field data collection phase was carefully planned with a constant view toward the end results of the analysis.

3. METHOD OF DATA ACQUISITION

3.1 General - The observed reliability of an electronic equipment in service use is affected by a number of factors. Basic to this figure of merit is the inherent capability of the design; however, usage, maintenance, and other environmental factors may have a marked effect on measured reliability. If a designed experiment is to yield valid and useful results, it is imperative to list and measure, in so far as possible, those factors believed to have significant influence on the final result. A useful standard has been prepared by the Electronic Industries Association for reporting reliability measurements.[4] Some of the factors known to affect observed reliability are listed below:

a. General climatic and equipment environmental conditions
b. Definition of the equipment or system
c. Criteria of adequate performance
d. Definition of failures
e. Operating time or time to failure
f. Operating or usage conditions
g. Maintenance practices
h. Sampling or estimating techniques (underlying assumptions)

3.2 Field Program Requirements - Field data acquisition at each site was performed in three consecutive phases as listed below:

a. Equipment and site general information
b. Short term measurement of equipment environment
c. Long range controlled data collection

3.2.1 Equipment and Site General Information - Appendix A of this report is an exhibit of the "Equipment and Site Information Questionnaire" that was used in the preliminary phase of the data collection at each site. The information was recorded under four general categories briefly described below:

a. AC&W Site Questionnaire - including information on terrain, physical surroundings, equipment locations, type of traffic handled, supply set up, etc.

b. Equipment Questionnaire - listing major operating units, equipment operation, test equipment used, operating instructions, history, modifications performed, and past failure data.

c. Maintenance Procedures - describing method of reporting, logs and forms used, daily, weekly and monthly checks performed, and other items.

d. Section (Personnel) Questionnaire - listing number of persons, military and civilian, experience, education, length of service, knowledge of equipment, training programs received, etc.

One of the most important areas of the Equipment and Site General Information phase was the logging of past data referred to in item (b) above. At least one year's data on equipment was transcribed from the various sources available. Sources of data were as follows:

AN/GRC-27	AN/FPS-3 and AN/GPX-20
Equipment Outage Logs	Radar Daily Log, ADC 151
AFTO Forms 43, 43A and 43B	Failure Record Card, ADC 155
Unsatisfactory Report (UR), AFTO 29	Work to Be Done Log, ADC 188
Failure Report Cards, DD 787	Failure Report Card, DD 787

These forms were screened and cross-checked with each other to obtain as accurate and quantitative data as possible. In some instances, information recorded on one form was omitted on the other. Questions arising during the processing were referred to the maintenance personnel for clarification. In general, information was more complete from the Radar Section, since they are required to complete daily logs.

3.2.2 Short Term Measurement of Equipment Environment - The two most important environment factors believed to influence ground equipment reliability are internal ambient temperature and line voltage level and variation. Accordingly, continuous monitoring of these values was obtained for several days on each equipment. Use of graph recorders made it possible to establish a definite time relation between equipment temperature changes, [illegible] ON time, in the case of the GRC-27. This was accomplished by having the chart paper on each recorder (the equipment temperature recorder) feed at an equal rate of speed. Starting time and date of each measurement was noted on the chart paper to enable correlation to be made between each type of equipment. Each recorder was monitored throughout the day to insure proper operation. No specific period of time was allotted for the recording of the various parameters, however, forty hours of recording proved to be adequate to provide sufficient information.

3.2.2.1 Temperature Measurement - During the reliability prediction phase of the program, internal equipment temperatures were monitored at many points throughout the equipment during typical operating modes. For the field program it was felt that a single measurement of exhaust air temperature would be sufficient for satisfactory correlation with the prediction and laboratory test measurements. The temperature measurement

was made by placing a copper constantan thermocouple, size number 24 or 25, in the exhaust air stream of the transmitter and the wire connected to a strip chart recorder to register continuous temperature reading. Thermal measurements on the FPS-3 and GPX-20 presented some difficulties since some of the equipment was located on a tower mounted rotating antenna. Recording devices protected by a weather cover were mounted on the rotating section. Checks could only be made when it was convenient for the operating and maintenance section to stop the rotating antenna.

3.2.2.2 Line Voltage Measurement - This was obtained by use of a continuous feed strip chart recorder using a center pen and two edge marking pens. To provide the proper voltage for the center pen, a dropping resistor and a rectifier was inserted in series with instrument AC power source to allow for the pen's one milliamp movement. One side marking pen was used to record power ON condition and the other carrier ON condition for the GRC-27. This was accomplished by connecting each to the appropriate relay circuit in the transmitter.

3.2.3 Long Range Controlled Data Collection - The purpose of the long range program was to collect daily information on equipment performance, failures, maintenance action, time, temperature and weather conditions and any other information that might affect observed reliability. This program was carried on by the Site Engineer, section engineers and military maintenance personnel. About ten months of continuous reporting on each equipment at each site was performed. Specially prepared log sheets were provided to insure reporting of sufficient detail to enable subsequent engineering evaluation and classification of observations. Typical forms used are contained in Appendix II of this report. There were three types of forms used:

a. Daily Log - to record all maintenance action, failures and their description, time and other pertinent observations.

b. Meter Checks - to record the measured value of the key equipment operating parameters on a daily basis. (Since the criteria of adequate performance was based on observed measurements of the major equipment operating characteristics, these measurements and the information recorded on the Daily Log formed the basis for failure interpretation and classification.)

c. Relative Humidity and Temperature Daily Log

Elapsed time meters were installed in the GRC-27 equipments to record accumulated [illegible] ON time. These meters were the 115

voltage type which were connected to the primary power transformer providing power for these specific functions. Time meters were not required for the FPS-3 or GPX-20 since there is a built in recorder on the main control unit.

3.3 Conduct of the Field Program

3.3.1 Planning and Coordination - Prior to selection of the ACW sites to be visited, coordination with the Central Air Defense Force headquarters was necessary. The status of all equipments and their availability for study was determined. The program at each site was activated by a field engineering team consisting of one engineer and one technician, who had had previous experience and knowledge of the equipments under study.

3.3.2 Orientation of Site Personnel - The key personnel at each site were briefed on the program procedure. This included an explanation of the goals, the procedures used, and the necessary support required from them. Maintenance section heads were given a thorough briefing on the procedures required of them during the controlled data collection phase. This was completed as soon as possible on arrival at the site so that the controlled data collection phase could be supervised during the informational and measurement phases. Instruction sheets explaining the required entries and proper procedures to follow were distributed to both sections. The data feedback system is shown in Figure 1, "Failure Data Feedback". In accordance with the program, Air Force maintenance personnel completed the logs. The logs were then collected by the RCA technical representatives, screened and submitted to the site engineer. After a general inspection for completeness, the logs were forwarded to the RCA Reliability Research Projects Office.

3.3.3 Obtaining the Data - In general, data pertinent to the assessment of reliability of each equipment was obtained in three ways:

a. From existing logs, technical orders, and other forms kept by the squadron,

b. From formal and informal conversation with personnel responsible for operation and maintenance of the equipment,

c. From direct observation of existing conditions.

The general information and short term measurement phases described in Section 3.2 above were accomplished simultaneously. During the latter

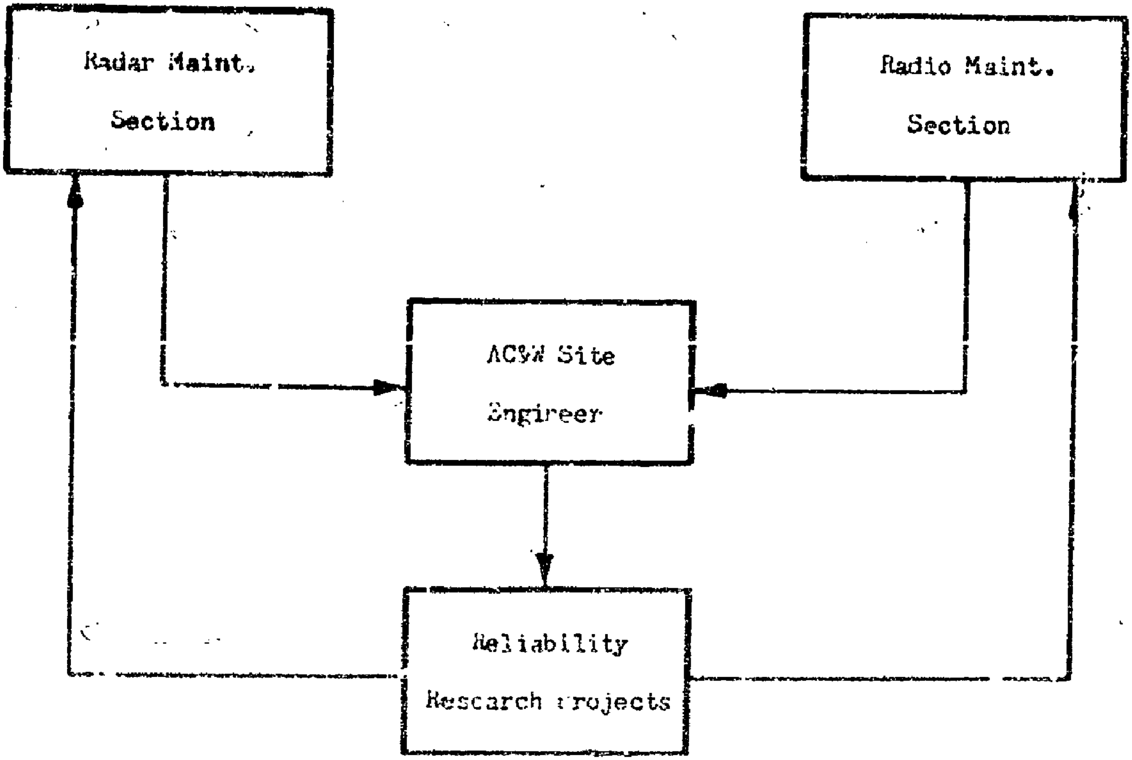

FIGURE 1   FAILURE DATA FEEDBACK

portion of the site visit the long-range data collection phase (3.2.3) was begun. There were some problems regarding the long-range data collection phase that could not be resolved until the program had been in operation a sufficient time to reveal questionable areas. Omissions in the log forms, for example, soon appeared. These problem areas were resolved through continued correspondence with the site engineer.

3.3.4 General Aspects of Field Data Collection - There is much valuable information available in the field which normally does not reach interested agencies through the present reporting methods (i.e. UR's and DD 787 Failure Report Cards). Due to the variety and quantity of paper work required from maintenance sections at each site, only the minimum amount of information is supplied. This often results in incomplete failure description. The case for the maintenance man is justified in many respects since his primary interest is to accomplish a thorough and rapid repair of the equipment whenever a failure occurs. The completeness of failure forms is of little significance to him, since, once the data leaves the site, results obtained from the data is almost never made known to those originating the information. Field personnel can be inspired to improve quality of equipment failure reports by including them in the results of various studies, recommendations, etc. resulting from the analysis of the failure data. This can only be done if an adequate feedback system is established between the field and various agencies appraising the data collected from such a program. During the conduct of the program described here, copies of all monthly letter progress reports and Interim Engineering reports have been furnished to each site to help instill a feeling of participation and interest in the project.

4. METHODS OF DATA REDUCTION AND ANALYSIS

4.1 Classification of Types of Data - The information collected during the three-phase program described in sections 3.2 is of two broad categories: (1) information about the site and equipment environment, maintenance policy and practice, equipment history and usage, personnel data, etc., and (2) observations of equipment performance, failures and their description and the maintenance action performed.

4.1.1 General Site and Equipment Information - The data of 4.1 (1) above will be used to compare measurements between equipments and sites, to correlate prediction and laboratory results with field observations and to determine the major modifying factors between inherent equipment reliability and that level actually achieved in service use. In general, this information is not suitable for automatic processing. It will be presented in the final report of this study where all reliability predictions, test results, and field measurements will be summarized.

4.1.2 Failure Data and Maintenance Action - The specific failure data and maintenance action of 4.1 (2) above has been collected for a period of nearly one year since the beginning of the field program. Past data, taken from site logs and other forms described in section 3.2, covered a period of approximately one year prior to start of the special field study. This data will be used to refine part failure rates which are basic to the prediction method. It will also be used to determine logistic support requirements. Since all factors necessary to a reliability estimate were not known during the period represented by the past data, it will not be used in the reliability calculation. The present data, collected since the start of the field study, therefore, will form the basis for determination of equipment reliability. The past and present data includes about 7000 replacements and requires automatic machine processing for maximum access.

4.2 Failure Classification and Interpretation

4.2.1 Classification - Every effort was made to select only those primary failures responsible for equipment malfunction in the calculation of equipment reliability. These are the so called "true random failures". In complex equipment composed of many classes and subclasses of parts having diverse failure rates as well as mixed ages of service, it can be expected and, in fact, has been demonstrated, that the aggregate failure rate of these parts will tend to be random in nature. The classification of failures is further described below under nine convenient types. In the examination of past history data only a rough interpretation of the nature of the failures was possible. By careful analysis of the daily log sheets obtained during the controlled data collection phase of the program (present failure data) it was possible to determine in most instances which replaced parts were true random failures. This was accomplished by considering the type of maintenance performed (scheduled or unscheduled), the nature of the failure (rapid deterioration of a key operation characteristic, etc.), operating time of the part prior to replacement, etc. Some specific equipment guidelines used in the interpretation of failure data are given in subsequent paragraphs. Failures were grouped in accordance with the following general failure classifications:

Type 1 True Random Failures - Those failures, primarily responsible for equipment malfunction, that occur within the operation time period after elimination of design defects and unsound parts and before the occurrence of known wearout phenomena are classed as Type 1. Any failures that can justifiably be assigned to one of the other eight categories should not be considered random failures. An example of a Type 1 failure is the random "open" occurring in a resistor wire after several hundred hours operation.

Type 2 Dependent Failures

(a) Secondary Failures - When parts fail as a direct result of a failure occurring in some adjacent part, the secondary failures are classified as dependent. It is common practice to search for serious overstressing of associated parts when a failure occurs. Sound maintenance practices anticipate this and replace parts in related groups where necessary to bring the equipment back to its initial state of readiness. Only the primary part failure can be included as a random independent failure in accordance with the exponential failure model used for reliability measurement.

(b) Parallel Failures - These failures are not secondary failures as we have defined them nor are they true random failures. They will not result in an immediate or imminent malfunction of the equipment. One can best define a parallel failure by giving examples:

1. A meter failure that does not result in equipment malfunction.

2. A portion of equipment that is not used under the present operating conditions but might be used with other pieces of equipment.

Type 3 Wearout Failures - Failures which can be avoided by preventive maintenance in accordance with a prescribed schedule. Examples of part types which fall into this category during the useful life of the equipment are vibrators, rapid action relays, blowers, motors and certain general and special purpose tubes.

Type 4 Initial Defectives - Parts which are not representative of the normal quality in that they contain defects or abnormal weaknesses which result in their early failure. These parts can occasionally be picked up during inspection, but are usually detected during the early hours of equipment operation, commonly referred to as the debugging period. As the defective parts are replaced by normally good ones the total population of initial defectives decreases exponentially.

Type 5 Performance Deterioration - The drift which occurs in parts under stress can cause an accumulation of tolerances to the point where marginal operation is observed. Such "malfunctions" are not equipment outages but have a seriousness directly controlled by the schedule of adjustments provided as part of the design intent. On this basis, [illegible] performance deterioration will constitute a true random failure only if it occurs ahead of schedule.

Type 6 Non-Operational Defects - These include parts which are replaced because of defects not affecting the actual operation of the system. Examples include manual controls which are replaced because they are difficult to operate (a stiff potentiometer) or the replacement of a tube with a cracked phenolic base while the tube continued to perform satisfactorily.

Type 7 Workmanship Items - These result from incorrect factory fabrication, assembly or processing of electronic parts, subassemblies, wires, mechanisms, etc. Sound factory techniques have demonstrated the ability to reduce such failures to a very low residue, through proper testing and inspection. Therefore, they are omitted from reliability predictions. These items include chance damage caused by personnel during testing and trouble shooting, solder spill-over, inadequate dressing of wires, scratches of panels, etc.

Type 8 Design Changes - These are replacements of types of parts or significant changes in the design introduced to achieve a higher performance capability or reliability level but not directly based upon evidence of failure occurrence.

Type 9 Design Error Failures - When equipment malfunctions occur repeatedly and can be traced to a specific faulty design, it is assumed that corrective action will be forthcoming. Such failures are a natural part of debugging the design, just as initially defective parts are debugged in the manufacturing process.

Some comments on the above classification are appropriate here. It can be anticipated that classification of failures is not easily accomplished. Some knowledge of the equipment, its operation and maintenance is essential. For example, the equipments studied have been operational for a number of years. Due to constant replacements the ages of the various parts are well mixed. Wearout failures and performance deterioration will appear more or less randomly. Since it is not a practice of CADF to keep a record of the ages of all parts, it is not always possible to distinguish between performance deterioration, wearout and true random failures. Generally, when parts were replaced during preventive maintenance to optimize equipment performance or to replace items suspected of impending failure, these items were assigned a Type [illegible] or 5 classification. However, primary failures that were not anticipated and resulted in non-scheduled maintenance to restore equipment to satisfactory operation, were given the Type 1 classification. Some wearout items are unavoidably included.

4.2.2 Failure Peculiarities of Equipment Maintenance and Operation - Knowledge of the peculiarities of maintenance practices and equipment

operation is essential in the classification of equipment failures. Experience in the field by the engineers carrying out the field reliability study on equipment included in the program made it possible to develop part failure interpretation aids for each equipment type. Specific considerations for each equipment are listed in the following paragraphs:

4.2.2.1 AN/FPS-3/MPS-7

a. It is often a practice to perform maintenance on Indicator OA-175 only when a major equipment failure occurs. At this time the unit is replaced with a spare unit if major maintenance is necessary.

b. Total failures from all indicators were considered to reach a mean life since the number of indicators varies from site to site.

c. The failure of R-3740 and R-3741 associated with V-3705 and V-3706 in AM-389 is normally caused by the failure of V-3703 or V-3704.

d. Any items listed as being burned out under preventive maintenance, should, if an independent failure, be classified as the true random type and as having occurred during a non-scheduled maintenance period.

e. Where a TR tube is indicated as burned out and is replaced during a preventive maintenance period along with a receiver crystal, the TR tube should be considered the true random failure which occurred prior to the preventive maintenance period and the crystal a dependent failure. Receiver crystal failures will only be considered as the true random type if the failures are independent. (Note - The repeated reference to failures occurring during a scheduled maintenance period has been brought about by a diversified maintenance schedule followed in several areas of CADF. This method allows for maintenance schedules to be generated from site level. When a failure is evident a maintenance period is generally granted and classified as a scheduled maintenance period rather than the rightful classification of non-scheduled maintenance. This system applies to the radar equipment).

4.2.2.2 AN/GRC-27

a. Where log entries fail to indicate whether a repair was accom-

plished during a scheduled or non-scheduled maintenance period, it will be assumed that the failure occurred during a non-scheduled maintenance period.

b. Tube types 4X150 and 2C39, replaced during a scheduled or non-scheduled maintenance period, must be closely screened to determine whether the failure should be classified as a true failure or a wearout failure. The length of time that elapsed since the previous failure was considered in the classification.

4.2.2.3 AN/UPX-20

a. The system includes two AN/UPX-6 TX-RX units and one KY-54 coder unit. One AN/UPX-6 unit is used as a spare to be interchanged periodically or in event of a unit failure.

b. A close check must be made to determine the proper reason for an AN/UPX-6 unit replacement.

c. It is a normal practice to perform maintenance on the KY-54 coder only when a failure occurs.

4.2.2.4 All Equipments - Where tubes are replaced during a scheduled maintenance period the number of operating hours which each tube had accumulated was estimated to provide information on wearout.

4.3 Physical Aspects of Data Handling

4.3.1 General - The quantity of failures obtained from the field warranted the use of machine processing to reduce and, to an extent, analyze the data. Figure 2, "Failure Data Reduction and Analysis Process", illustrates the steps necessary to acquire usable information from the raw data.

4.3.2 Failure Data Accounting and Screening - Equipments from which failure data was obtained were assigned a numerical identifier code. Site and equipment identifiers are shown in Table 1, "Site and Equipment Coding, Field Reliability Study". Each equipment failure was then processed with the site identifier and equipment identifier. Failure data was taken from the logs, which had been processed as shown in Figure 1, and screened for completeness. Where there were omissions on the log sheets, the site engineer originating them was notified of the discrepancy and requested to supply the missing information.

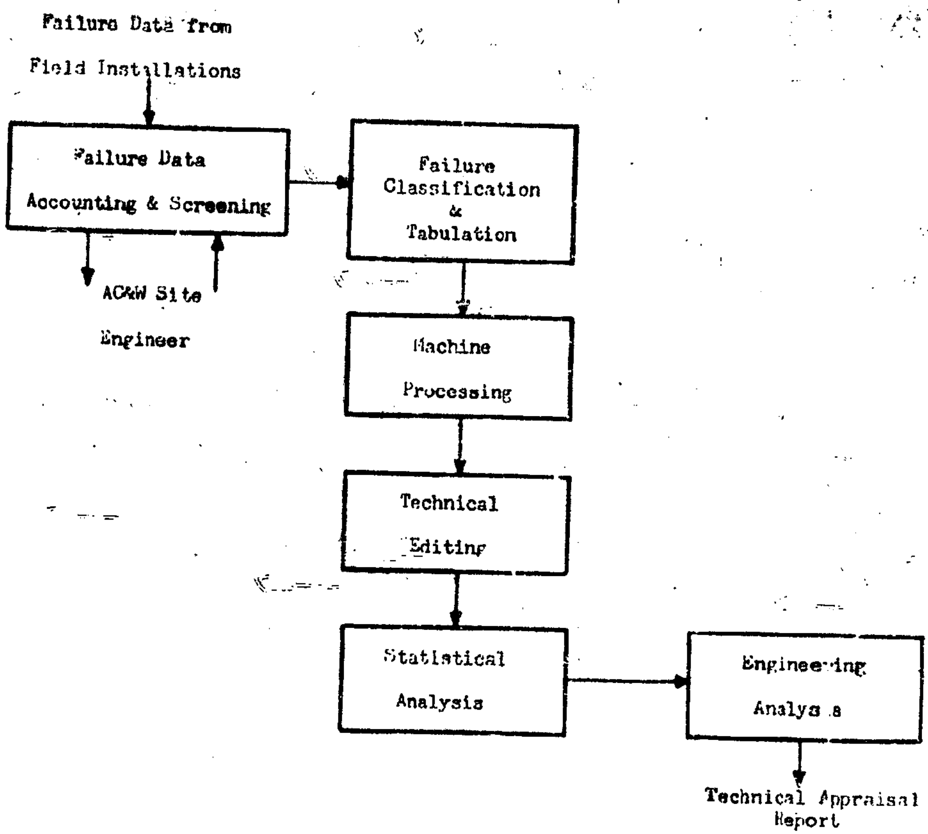

FIGURE 2 FAILURE DATA REDUCTION AND ANALYSIS PROCESS

TABLE 1

SITE AND EQUIPMENT CODING
FOR FIELD RELIABILITY STUDY

Site No.	Set No.	Equipment Nomenclature
1	* 1	AN/GRC-27
	2	AN/GRC-27
	3	AN/FPS-3
	4	AN/GPX-20
2	* 6	AN/GRC-27
	7	AN/GRC-27
	8	AN/MPS-7
	9	AN/GPX-20
	** 10	AN/GRR-7 & AN/GRT-3
3	* 11	AN/GRC-27
	12	AN/GRC-27
	** 13	AN/GRR-7 & AN/GRT-3
	14	AN/MPS-7
	15	AN/GPX-20
4	* 16	AN/GRC-27
	17	AN/GRC-27
	** 18	AN/GRR-7 & AN/GRT-3
	19	AN/MPS-7
	20	AN/GPX-20

* Equipped with elapsed time meter

** Equipped with elapsed time meter. Single channel UHF data collected for supplementary information.

4.3.3 Failure Classification and Tabulation

4.3.3.1 General - The failure classification and tabulation stage of data processing was one of the most important steps in the reduction and analysis of field data. A careful engineering analysis was made of each failure and these failures assigned to one of the failure classifications outlined in paragraph 4.2. The daily record of readings of the important equipment electrical parameters was consulted, where necessary, to properly classify the observation.

4.3.3.2 Tabulation Sheet - The failure information was coded and transferred to a tabulation worksheet, "USAF Ground Electronic Equipment Failure Report Tabulation Sheet", Figure 3. The tabulation sheet is necessary to insure that the raw data is reduced to a form suitable for transfer to the IBM card. It is comprised of 80 columns with 22 groups within these columns for information regarding each observation. The worksheets were then used to transfer the information to an 80 column electrical accounting machine card (shown in Figure 4, "Field Failure Report Card".) Coding is used on these worksheets to utilize all the information pertaining to each observation. A description of each column group and the coding used follows (refer to Figure 3 for column numbers):

Report Number (1) - Each failure was assigned an accounting number for identification purposes. Each failure for a particular equipment was numbered in order of occurrence. Six spaces provided.

Date of Failure (2) - This is the date when the failure occurred or part was replaced as indicated on the daily log sheets. The numerical equivalent of the month and the last two digits of the year are used following the month-day-year sequence. Five spaces provided.

Circuit Symbol (3) - This is the symbol used to identify the part in the equipment (i.e. V-1507, R-2138, etc.) Six spaces provided, two spaces for letter code and four spaces for number code.

Site Number (4) - This is the site designator number from which the equipment part failure originated (see Table 1). Two spaces are provided, one being an extra space for additional sites.

Equipment Type (5) - The equipment types are coded as follows.

RCA SERVICE CO. INC.
GOVERNMENT SERVICE DEPT.

USAF GROUND ELECTRONIC EQUIPMENT FAILURE REPORT TABULATION SHEET

RELIABILITY AND DATA PROCESSING GROUP

1	2	3	4	5	6	7	8		9	10	11	12	13	14	15	16	17	18	19	20	21	22
REPORT NUMBER	DATE OF FAILURE (Mo, Day, Yr)	CIRCUIT SYMBOL (Letter Code, Number Code)	SITE NO.	EQUIP. TYPE	EQUIP SET NO	MAJOR UNIT	ASS'Y OR SUB-ASS'Y		PART NAME OR TUBE TYPE	PART VEN-DOR	[illegible]	[illegible]	DOWN TIME	RE PAIR TIME	CARRIER-ON OR FX-ON TIME HOURS	EQUIP LOG TIME HOURS	PART TIME IN SERVICE HOURS	[illegible]	FAILURE DESCRIP TION	TYPE OF FAIL-URE	[illegible]	[illegible]
1 2 3 4 5 6	7 8 9 10 11	12 13 14 15 16 17	18 19	20 21 22	23 24 25	26 27 28 29 30 31	32 33 34 35 36 37	38 39	40 41 42 43 44 45	46 47 48	49	50	51 52 53	54 55 56	57 58 59 60 61	62 63 64 65 66	67 68 69 70 71	72	73 74 75	76 77 78	79	80

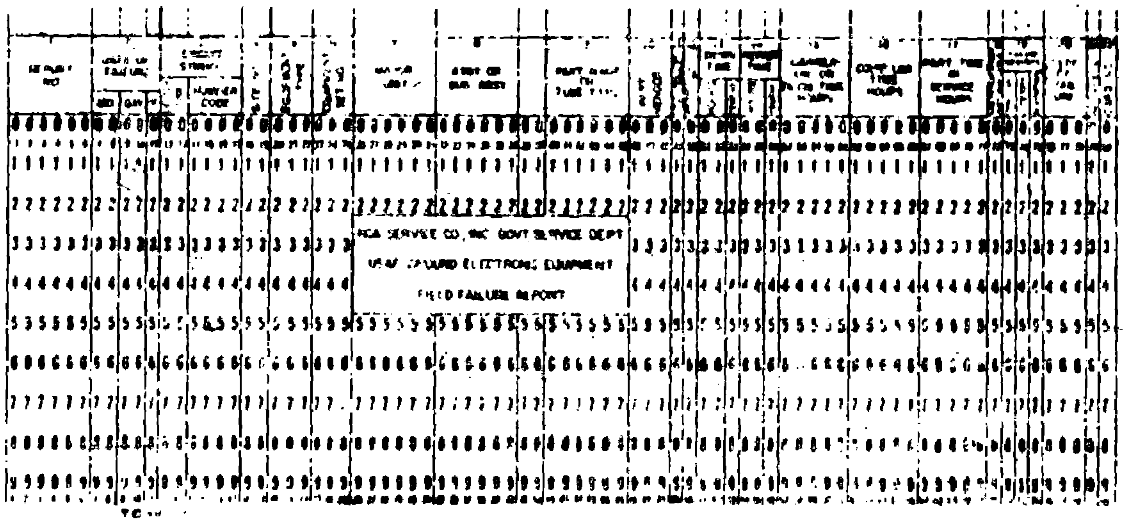

FIGURE 4. USAF GROUND ELECTRONICS EQUIPMENT
FIELD FAILURE REPORT CARD

Type	Code
AN/FPS-3	FP[illegible]
AN/MPS-7	MP7
AN/GR -27	G27
AN/GPX-20	X2
AN/GRR-7, GRT-3	G73

Equipment Set Number (6) - Each equipment is c[illegible] [illegible]cally (see Table I) which is associated with a given site. [illegible]r [illegible]ple, set #1 can be translated from a master equipment list as [illegible]ing of:

Type	Serial No.	Manuf[illegible]urer
T-217A	104	Dalco
R-278	2029	Collins
MD-129	1026	Collins

Major Unit (7) - No coding is required. Six spaces provided.

Assembly or Subassembly (8) - No coding required. Six [illegible]ces provided.

Blank Space - This space is used to identify types of parts. See Appendix III, "Breakdown of Parts as a Class into Various Subclasses".

Part Name or Tube Type (9) - Part name, such as relays, resistors, capacitors or the tube designator (i.e. 6AK5, etc.) is entered.

Part Vendor (10) - The first three letters of part m[illegible]facturer are used. Where the name of the manufacturer consists of two or more words, the first letter of each word is used. Three spaces provided.

First Indication of Trouble (11) - The first indication of trouble is described by one of the following codes:

Code	Description
1	Inoperative
2	Intermittent
3	Low Performance
4	Noisy
5	Off Frequency
6	Out of Adjustment
7	Overheating
8	[illegible]
9	Others

[illegible]

Operational Conditions (12) - One of the following codes indicates the condition of the equipment caused by the failure:

(1) Code 1 - Equipment operating with reduced capabilities due to this failure.

(2) Code 2 - The equipment out of commission due to this failure.

(3) Code 3 - The equipment operating without any reduced capabilities due to this failure. One space is provided.

Down Time (13) - The recorded duration in hours and tenths that the equipment was inoperative during an operational condition. Three spaces provided.

Repair Time (14) - This is the actual time required to repair a failure in hours and tenths. Three spaces provided.

Carrier ON or TX ON Time (15) - This is the cumulative reading in hours of the period during which the transmitter is radiating. Five spaces provided.

Equipment Log Time (16) - This is the reading in hours of equipment ON time from the start of the controlled data collection phase of the program. Five spaces provided.

Part Time in Service (17) - This is the time, to the nearest hour, that the part functioned prior to removal or repair. Five spaces provided.

Was Replacement Part Available (18) - The entry here is y (yes) or n (no). One space is provided.

Failure Description (19) - This area is broken down into three dependent sections considered necessary to fully describe failures. The entire success of the field program is dependent on a complete evaluation in this section. The sections are broken down for both past and present data. The sections are coded numerically in the following manner:

A. Type of Replacement - One space provided.

Past Data	Present Data
1. Non-scheduled replacement	1. Non-scheduled period
2. Preventive maintenance period	2. Preventive maintenance period

B. Category - One space provided.

Past Data

1. Electrical, electronic, electro-mechanical
2. Mechanical

Present Data

3. Electrical replacement
4. Electrical adjustment
5. Electrical repair
6. Mechanical replacement
7. Mechanical adjustment
8. Mechanical repair
9. Unit replacement

C. Description - One space provided.

Past Data

1. True random failure
2. Performance deterioration (rapid)
3. Equipment malfunction corrected by unit replacement
4. Equipment malfunction corrected by adjustment
5. Wearout failure
6. Non-operational failure
7. Dependent failure
8. Other - describe in detail

Present Data

1. True random failure
2. Dependent failure
3. Wearout failure
4. Performance deterioration
5. Non-operational failure
6. Others - describe in detail (damage, overhaul team, modification, etc.)

Note: It will be noticed that the failure description here does not exactly follow the general classification given in section 4.2. The reason is that certain types such as workmanship items, design errors, or changes, and initial defectives do not frequently apply to mature, debugged equipment in the field. In place of these infrequent items, a code number 6 on the present data and 8 on the past data, "Others", is used. This calls for a trailer card to fully explain the entry; this is also printed on the run-off sheets. The description of failure types presented in section 4.2 is intended as a general guide for use as appropriate on any equipment at any stage in its design-production-use cycle.

Types of Failures (20) - Failure types are those described by the standard Air Force code list describing various types of failures and used with the DD 787 forms. Three spaces provided.

Past or Present Data (21) - Observations are coded with a one (1) to indicate they have been taken from past history log sheets and two (2) to indicate present data origin. One space provided.

Card Number (22) - One electrical accounting machine card is not always sufficient to explain a failure. In such cases a "trailer card" is

ured. Failure information placed on these cards is not coded. The original card and any "trailer cards" are coded numerically in sequence. The [illegible] Number, column 1, which appears on the original card is entered on each "trailer card" for identification purposes. One space is provided.

4.3.4 [illegible] - All of the information presented on the tabulation worksheet is transferred to the 80-column electrical accounting machine card (Figure 4) by use of a key punch machine. The information is in the form of holes, which permit the card to be sensed by electrical circuits of the sorting and tabulation equipment. The cards, when punched, are verified, sorted and tabulated by additional machine processing.

4.3.5 Technical Editing - To insure the accuracy and consistency of all data passing through the statistical system, technical editing is accomplished by means of a test tabulation. The test tabulation reveals inconsistencies in sequence or logic or omissions of data.

4.4 Statistical Analysis

4.4.1 Sorting - Prior to machine tabulation or run-off, the cards must be sorted into some convenient and logical sequence. Sorting, a machine process, may be made by equipment type, by location, by part replaced, by failure cause, or any of a large number of ways; the sort may include principal and minor [illegible]ngs. For this study a total of eight separate sorts were made to permit maximum availability of data. The sorts are summarized below:

Past and Present Data in Sequence

1. By chronological date of failure
2. By circuit symbol and date of failure
3. By part description within major part categories

Present Data in Sequence

4. By time interval for true random failures
5. By failure description (wearout, dependent, true random, etc.)
6. By down time for each assembly and/or major unit
7. By repair time for each assembly and major unit
8. By "[illegible]mitter-on" [illegible]

4.4.2 Statistical Summary or Run-Off Tabulations - Figure 5, "Sample IBM Run-Off Sheet", is an illustration of a portion of a typical machine run-off that was made from the sorted cards. The example shown here is

Period of Test 28 March 1957 thru 31 December 1957. Time Meter Reading Start of Test 1870 Hours, Completion 8270 Hours

1 RPT NO	2 DATE	3 CKT SYM	4 SI NO	5 SQP TYP	6 SET NO	7 MAJ UNIT	8 ASSY	PT	9 PT OR TUBE	10 PART VEND	11 TEL IND	12 OPR CON	13 DOWN TIME	14 REP TIME	15 TX TIME	16 LOG TIME	17 PART TIME	18 PT AV	19 FAIL PCD	20 TYPE FAIL	21 P P	22 CD NO
1300	03317	V 8521#	1	FP3	3	OA175	PP552	DA	2X2A		1	1	.5	.2		1916		Y	131	004	2	1
1301	03317	V 8521	1	FP3	3	OA175	PP552	DA	2X2A		1	1		.2		1916		Y	134	004	2	1
1312	04087	V 8521#	1	FP3	3	OA175	PP552	DA	2X2A		1	1	.3	.3		2118		Y	131	004	2	1
1456	08157	V 8521	1	FP3	3	OA175	PP552	DA	2X2A			3	1.0	.2		5113		Y	234	700	2	1
1546	10107	V 8521	1	FP3	3	OA175	PP552	DA	2X2A			3		.2		6437		Y	234	700	2	1
1603	10267	V 8521	1	FP3	3	OA175	PP552	DA	2X2A			3		.2		6816		Y	234	700	2	1
		2 *																		6*		
1311	04077	V 8522#	1	FP3	3	OA175	PP552	DA	2X2A		1	1		.3		2093		Y	131	004	2	1
1547	10127	V 8522	1	FP3	3	OA175	PP552	DA	2X2A			3		.2		6437		Y	234	700	2	1
1588	10177	V 8522	1	FP3	3	OA175	PP552	DA	2X2A			3		.2		6622		Y	234	700	2	1
1661	11237	V 8522#	1	FP3	3	OA175	PP552	DA	2X2A		1	1	.3	.2		7473		Y	131	920	2	1
1710	12287	V 8522#	1	FP3	3	OA175	PP552	DA	2X2A		3	1		.2		8198		Y	131	920	2	1
1710										Scope Would Not Focus												2

True Random Failure of V 8522 → 3 *

Total Replacements of Part V 8522 → 5*

Total of OA175 → 131*

Total of Assy PP552 → 58*

1 RPT NO	2 DATE	3 CKT SYM	4 SI NO	5 SQP TYP	6 SET NO	7 MAJ UNIT	8 ASSY	PT	9 PT OR TUBE	10 PART VEND	11 TEL IND	12 OPR CON	13 DOWN TIME	14 REP TIME	15 TX TIME	16 LOG TIME	17 PART TIME	18 PT AV	19 FAIL PCD	20 TYPE FAIL	21 P P	22 CD NO
1529	10097	V 5204	1	FP3	3	OA179	C 708	AD	12AU7			3	1.0	.2		6433		Y	234	004	2	1
1531	10097	V 5204	1	FP3	3	OA179	C 708	AD	12AU7			3		.2		6433		Y	234	004	2	1
																				2*		
1530	10097	V 5209	1	FP3	3	OA179	C 708	AD	12AT7			3		.2		6433		Y	234	004	2	1
1532	10097	V 5209	1	FP3	3	OA179	C 708	AD	12AT7			3		.2		6433		Y	234	004	2	1
																				2*		
1533	10097	V 5210	1	FP3	3	OA179	C 708	AE	6AQ5			3		.2		6433		Y	234	700	2	1
																				1*		
						5*																5*
1438	07317	W #	1	FP3	3	OA318		A				1		1.5		4789			151	099	2	1
1438										Trigger Cable Bad Fr Maint Room to Scope												2
1438																						3
		1 *																		1*		

Original and Trailer Card Identifying Numbers

Trailer Cards (2 & 3)

FIGURE 5 SAMPLE IBM RUN-OFF SHEET

a portion of sort #2, described in the preceding paragraph. The data presented is from the AN/FPS-3 at Site 1. The data is totaled by equipment groups and subtotaled by assemblies and circuit symbols. True random failures are indicated by a # sign, and totaled according to circuit symbol. For example, there were three true random failures out of a total of five replacements of part V-8522 located in assembly PP-552 of Group OA-175 of the AN/FPS-3. The principal results of the field observation program are derived from these run-off sheets.

4.4.3 Sample Presentation of Data - Statistical summaries of the essential failure, replacement, and maintenance data are presented in the following tables (ref. Figure 5):

Table 2 - "Replacements and True Random Failures by Major Part Categories for AN/FPS-3, Site 1". The total number of true random failures by part category is obtained in this type of run-off by adding up all the subtotals of true random failures appearing under column group 3, "CKT SYM". The total number of replacements by part category is obtained by adding the subtotal figure which appears under column 20, "TYPE FAIL".

Table 3 - "Total Replacements, True Random Failures and Maintenance Time by Groups for AN/FPS-3, Site 1". The data extracted by major equipment groups is presented here. It is obtained from column group 7, "MAJ UNIT". Down time and repair time come from column groups 13 and 14.

Table 4 - "Failure Description by Major Part Categories for AN/FPS-3, Site 1". A summary of replacements by failure description is obtained from column group 19, "FAIL PCD". The numbers 1-6 refer to the failure description.

4.4.4 Estimate of Equipment Reliability - From the data presented above, the reliability of AN/FPS-3 at Site 1 may be estimated:

Total Operating Time (T) = 6399 hours
Total True Random Failures (F) = 115
Estimate of Equipment Mean Life (M) $= \frac{T}{F} = \frac{6399}{115} = 56$ hours

Figures 6, "Probability Limits for the Poisson Distribution", shows that the estimated mean life is between $\frac{6399}{98}$ and $\frac{6399}{132}$ or 48 to 65 hours.

TABLE 2

REPLACEMENTS AND TRUE RANDOM FAILURES BY
MAJOR PART CATEGORIES FOR AN/FPS-3, SITE 1*

Part Category	Circuit Symbol	Total Replacements	Total True Random Failures
Tubes, Special	V	147	46
Tubes, Receiving	V	151	36
Resistors	R	15	7
Capacitors	C	2	2
N-type Crystals	CR	53	9
Coils	L	2	1
Connectors	J	5	1
Cables	W	9	7
Switches	S	1	1
Relays	K	1	1
Transformers	T	2	1
Cavities	Z	3	1
Filters	Z	2	
Gears	MP	1	1
Blowers-Motors	M	1	
Terminals	E	2	1
Total		398	115

* For reporting period 28 March through 31 December 1957
Total operating time 6399 hours

TABLE 1

TOTAL REPLACEMENTS, TRUE RANDOM FAILURES, AND MAINTENANCE TIME BY GROUPS FOR AN/FPS-3, SITE 1*

Groups	Total Replacements	Total True Random Failures	Down Time	Repair Time
Generator OA-174	5	3	6.3	2.5
Indicator OA-175	134	43	45.9	27.5
Control OA-179	6	1	1.3	1.2
Receiver OA-318	50	19	20.0	16.0
Blanker Indicator OA-319	1	1	2.0	.5
Transmitter OA-398	193	47	180.7	69.7
Antenna AB-180	2	1	1.5	.9
Miscellaneous	1	0	.4	.4
Totals	392	115	258.0	151.50

* For reporting period 28 March through 31 December 1957
Total operating time 6399 hours

TABLE 4

FAILURE DESCRIPTION BY MAJOR PART
CATEGORIES FOR AN/FPS-3, SITE 1*

Parts	Part Symbol	Failure Description - Column 75						
		1	2	3	4	5	6	Total
Tubes	V	82	13	48	145		11	299
Resistors	R	7	6				2	15
Capacitors	C	2						2
N-type Crystals	CR	9	25		13		6	53
Coils	L	1			1			2
Connectors	J	1		1	2		1	5
Cables	W	7					2	9
Switches	S	1						1
Relays	K	1						1
Transformers	T	1					1	2
Cavities	-	1					2	3
Filters	Z	0					2	2
Gears	ME	1						1
Blower-Motors	B			1				1
Terminal	E	1		1				2
Totals		115	43	54	161	0	27	398

* For reporting period 28 March through 31 December 1957
Total operating time 6399 hours

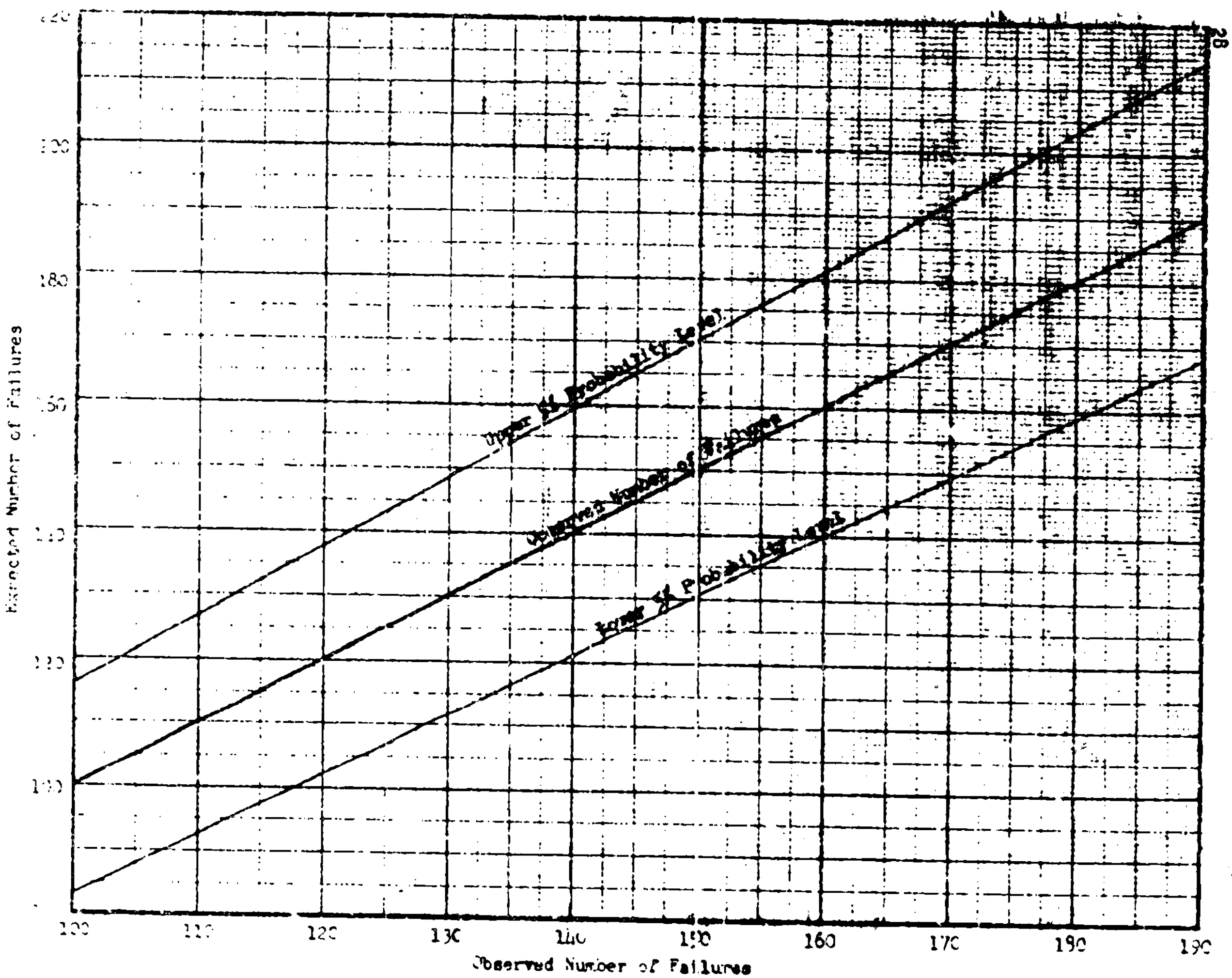

FIGURE 6 PROBABILITY LIMITS FOR THE POISSON DISTRIBUTION (90% CONFIDENCE)

4.5 Engineering Analysis - There are a number of profitable ways by which the data can be further analyzed from the complete and detailed summaries provided by the run-off tabulations. For example:

(1) Which classes or subclasses of parts represent the highest failure contribution on each equipment?

(2) Which individual circuit elements within classes have the highest failure rates?

(3) Where are the most significant part misapplications?

(4) What items or areas account for the largest amount of maintenance time?

(5) What items account for the largest portions of support cost?

These items are admittedly important. However, the main purpose of the entire prediction study is to perfect a prediction technique which will correlate reasonably well with field observation. The emphasis is, therefore, not on how existing equipment can be improved, important as this may be, but rather how can new equipments be designed and produced with a high operational reliability, and with a minimum of the ills that plague our present day operational equipments.

4.5.1 The Reliability Function - Basic to the measurement and correlation of field reliability with prediction or test results are the assumptions made in the field measurement. One of the principal assumptions made in presenting the reliability estimate of paragraph 4.4.4 above is that the equipment failure rate is constant - the occurrence of failures is distributed as a Poisson. If the failure rate increases or decreases with time, or if failures are unnaturally clustered, the above estimate is probably not the best measure of equipment reliability. It is, therefore, necessary to test the assumption of constant failure occurrence. The following test is an example of the engineering analysis that will be performed on each equipment at each site to determine the validity of the reliability measurement.

4.5.2 The Kolmogorov-Smirnov Test - Table 5, "Observed and Theoretical Reliability Functions for AN/FPS-3, Site 1", presents the data of Table 2 in a different form. A run-off tabulation similar to that shown in Figure 5, but arranged by date of failure was prepared. From this tab, the intervals between true random failures were obtained. These intervals are accumulated in the first two columns of Table 5. The next column shows cumulative probability. The fourth column presents the

TABLE 5

OBSERVED AND THEORETICAL RELIABILITY FUNCTIONS FOR AN/FPS-3, SITE 1*

Interval Between Failures (Hrs)	Failures (Cumulative)	Probability (Cumulative)	Expected Probability ($e^{-t/55.5}$)	Absolute Difference Between Observed and Expected Prob.
0 or more	115	1.00	1.000	.000
20 or more	80	.70	.697	.003
40 or more	55	.48	.486	.006
60 or more	40	.35	.340	.010
80 or more	30	.26	.237	.023
100 or more	24	.21	.165	.045
120 or more	23	.20	.116	.084
140 or more	20	.17	.080	.090
160 or more	16	.14	.059	.081
180 or more	13	.11	.04	.070
200 or more	9	.08	.027	.067
220 or more	7	.06	.019	.041
240 or more	7	.06	.013	.047
260 or more	7	.06	.010	.050

* Observed failures for reporting period 28 March through 31 December 1957.

theoretical probabilities of failure occurrence within the intervals listed, assuming a mean time to failure of 55.5 hours. The last column shows differences between theoretical and observed values. This information is shown graphically in Figure 7, "Observed and Theoretical Reliability Function for AN/FPS-3, Site 1".

The Kolmogorov-Smirnov, or D Test as it is sometimes called, is performed as follows:

(1) Refer to Table 5 and select the largest absolute difference between the observed and expected probability. From the table, the largest value is .09.

(2) Refer to Table 6, "Critical Values of D in the Kolmogorov-Smirnov One-Sample Test", and determine level of significance. For a sample of 115 observations, D at the 5% level is $1.36/\sqrt{115} = .127$. Even at the 20% level D = .10.

(3) From this test, by comparing these values with the .09 value in (1) above, it is concluded that the observed data fits the exponential curve reasonably well. The mean life estimate of 56 hours is, therefore, a valid estimate of FPS-3 reliability at Site 1 over the period and under the conditions of observation.

5. CONCLUSIONS AND RECOMMENDATIONS

The comparisons and correlations of prediction and laboratory test results with field observations is beyond the scope of this report These findings will be contained in the forthcoming final report. The techniques of field data collection, reduction and analysis have been described and demonstrated here in some detail. From this program, the following conclusions are derived:

(1) Much valuable information associated with equipment design, operation, maintenance and reliability can be obtained from Air Force operational squadrons that is not normally reported in a manner to permit ready access or valid interpretation.

(2) The methods described in this report constitute a practical procedure to spotlight and focus clearly on the reliability of ground electronic equipment in the natural environment and under the conditions of service use.

(3) Field personnel are anxious to cooperate in the collection and feedback of vital equipment operation and failure data.

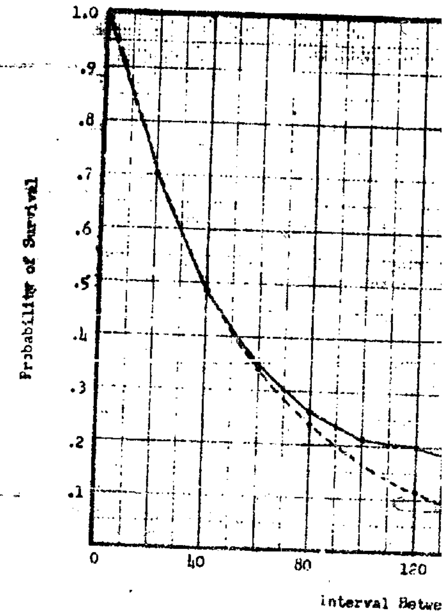

FIGURE 7 OBSERVED AND THE
FUNCTION FOR AN/

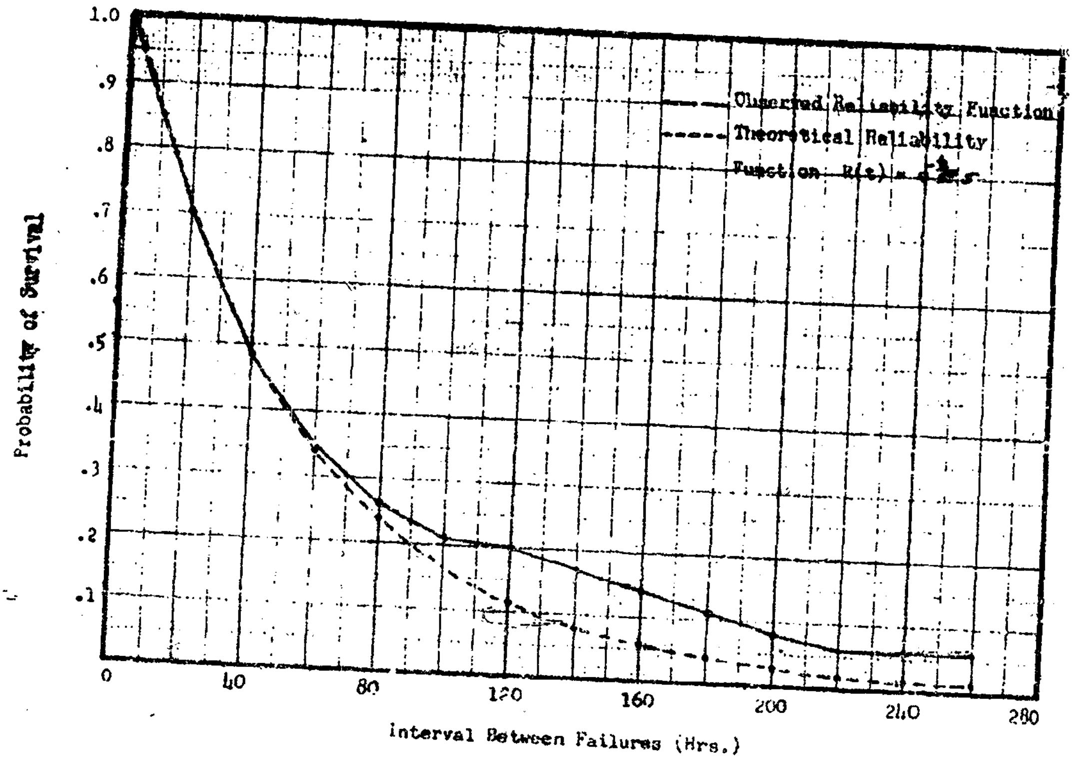

FIGURE 7 OBSERVED AND THEORETICAL RELIABILITY FUNCTION FOR AN/FPS-3, SITE 1

TABLE 6

CRITICAL VALUES OF D IN THE
KOLMOGOROV-SMIRNOV ONE-SAMPLE TEST*

Sample Size (N)	Level of Significance for D = Maximum $\lvert F_o(X) - S_n(X) \rvert$				
	.20	.15	.10	.05	.01
5	.446	.474	.510	.565	.669
10	.322	.342	.368	.410	.490
15	.266	.283	.304	.338	.404
20	.231	.246	.264	.294	.356
35	.18	.19	.21	.23	.27
Over 35	$\frac{1.07}{\sqrt{N}}$	$\frac{1.14}{\sqrt{N}}$	$\frac{1.22}{\sqrt{N}}$	$\frac{1.36}{\sqrt{N}}$	$\frac{1.63}{\sqrt{N}}$

* Extracted from Massey, F. J., Jr., 1951. The Kolmogorov-Smirnov Test for Goodness of Fit. "Journal of American Statistical Association", Vol. 46, p. 70, with permission of the author and publisher.

This information is extremely valuable and can provide the missing link between design concepts and mature, reliable equipment in the custody and environment of the user. Feedback is a two-way street; the value and quality of information that comes from the field depends to a large extent on the degree to which field personnel are included on the team and can see concrete results from their efforts.

(4) The data collection in this field survey is an exceedingly small sample, confined to operating squadrons within the Central Air Defense Force command. More complete knowledge of the effects of environment, usage, maintenance and logistic support on equipment reliability requires a representative study of equipments in other Air Force commands throughout the world.

(5) Although the program described here has provided invaluable information toward the development and refinement of a reliability prediction method, it is admittedly too expensive to apply routinely to all equipments in the field. However, it is evident that some practical means must be found for routine, valid measurement of reliability on all types of equipment in the field. This knowledge would provide a gauge or measure of the reliability status on which intelligent action of the maker and user could be based.

(6) The techniques of equipment observation, data collection, processing, and analysis for reliability measurement described here can be applied to the study of other areas by similarly focusing attention on the essential underlying variables. For example, a study of maintainability and its effect on equipment total cost and value to the user is an area that urgently requires increased attention by Industry and the Military today.

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4. Electronic Industries Association (formerly RETMA), "A General Guide for Technical Reporting of Electronic Systems Reliability Measurement", prepared by M-5 Systems Committee, December 1956.

5. RCA Service Company, A Division of the Radio Corporation of America, "Establishment of Methods and Procedures of Testing for Reliability in Ground Electronic Equipment", R-5-57, Contract AF30(602)1623, 1 December 1957.

APPENDIX I

EQUIPMENT AND SITE GENERAL INFORMATION QUESTIONNAIRE

INDEX

1. AC&W SITE QUESTIONNAIRE

1.1 General conditions surrounding site (as to population and terrain)

____

____

____

1.2 Unusual environmental conditions surrounding site (Elec. disturbances, nature or otherwise)______________________________

____

____

1.3 General location of equipment within the site (Also in regards to other electronic equipment)______________________________

____

____

1.4 Type of traffic handled (light, medium, heavy) Explain______________________________

____

____

1.5 Supply Adequacy: a. Unit______ b. Tech______ c. Depot______

Explain______________________________

____

____

1.6 Remarks______________________________

____

____

2. EQUIPMENT QUESTIONNAIRE, GRC-27

2.1 Major Operating Units	1.a. Location (within and/or out of what building)	1.b. Unusual environmental conditions
Radio Receiver (R-278/GR)		
Radio Transmitter (T-217/GR)		
Mod. Power Supply (MD-129/GR)		
Antenna (AS-505/GR)		
Antenna (AT-195/GR)		
Distribution Panel (J-390/GR)		
Control-Indicator (C-806/GR)		

2.2 Are Running Spares and Bench Stock adequate? ______________________

2.3 Power Source	a. Local or Commercial	b. Time in Switching from each

2.4 Test Equipment ______________________

a. Is specified test equipment available? ____________ Explain ______________________

____

b. Is calibration current? ____________ Explain ______________________

____

2.5 Equipment Operation

a. Technical Requirements ________________________________

____

b. Tactical Use ____

____

2.6 Equipment Instructions

a. Tech. Orders (Are they kept up to date?) ____________________

____

b. Maintenance and Operational Handbooks (Are they adequate?) ____

____

c. O.J.T. Program (Is it satisfactory?) ______________________

____

d. Formal Training (Mil. Schools) __________________________

____

e. S.O.P.'s (Squadron Operating Policies) ____________________

____

2.7 Remarks ____

____

____

____

____

____

____

2.8 History

a. Brief Description ____________________

____

b. Present Operating Condition ____________________

____

c. Modifications

Description	T.O. Authorization	Date Completed

d. Previous Failure Data (See next page)

d. PREVIOUS FAILURE DATA

SET NO.________

Unit	Ser. No.	Ass. or Sub-Ass.	Ser. No.	Circuit Symbol	Description of Malfunction or Failure	Down Time	Time Meter Read	Repair Time	Hrs. in Service	Sched. Rep.	Nonsched. Rep.

3. Maintenance Procedures Questionnaire

Equip. ____________

3.1 How are failures reported to technicians? (Verbal and/or written) ____________

3.2 Do technicians work in teams or singly? ____________

3.3 Types of maintenance logs available

Types of maintenance logs available	A	B	C	D	E	F	G	H	I	J	K	L

3.3 Does it show: (yes or no)

a. Whether each maintenance item was scheduled or non-scheduled?
b. Symptoms reported by operator?
c. Effects of failure on site operation?
d. Date and time of operator's report?
e. Operator's name?
f. Symptoms noted by technician?
g. Corrective action taken?
h. Parts replaced?
i. Repair time (hours or man/hours)?
j. Technician's name(s)?
k. Date and time equipment returned to service
l. Downtime of equipment? (time that an equipment remains unavailable for use because it will not function properly)

3.4 Are there any obvious errors in the log?

3.5 Is a record of the hours of operation available?

3.6 Are there any regulations concerning entries in the log?

3.6a. How strictly are they enforced?

3.7 Daily Checks

3.8 Weekly P.M.

3.9 Monthly P.M.

3.10 Remarks

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4. Section (Personnel) Questionnaire

Name of section	4.2 Number of men assigned to section	4.3 Method	4.4 [illegible] area the [illegible]
[illegible]	4.6 Average length of [illegible]	4.7 Average length of time at [illegible]	4.8 [illegible]

a. [illegible]
b. [illegible]
c. [illegible]
d. [illegible]
e. [illegible]
f. [illegible]
g. [illegible]

EQUIPMENT DAILY OPERATION AND MAINTENANCE LOGS

INDEX

SITE ________ SET NO. ________

GRC-27
DAILY LOG

DATE

TIME	

SUMMARY

EQUIP.	SER. NO.	CIR. SYM.	DESCRIPTION OF MALFUNCTION OR FAILURE	DOWN TIME	CARRIER-ON TIME	POWER-ON TIME	REPAIR TIME	HRS. IN SERVICE	SCHED REP.	NONSCD REP.

	DAILY	WEEKLY	MONTHLY
TX CARRIER ON TIME			
TX POWER ON TIME			
RX POWER ON TIME			
SCHED. MAINT. TIME			

SITE ________ FPS-3 or UPX-6 DAILY LOG SET NO. ________

DATE

TIME	

[illegible]

[illegible]	SER. NO.	ASS. OR SUB-ASS.	SER. NO.	CIRCUIT SYMBOL	DESCRIPTION OF MALFUNCTION OR FAILURE	DOWN TIME	TIME METER READ.	REPAIR TIME	HRS. IN SERVICE	SCHED REP.	NONSCHED REP.

	DAILY	WEEKLY	MONTHLY
Time Meter Reading			
Sched. Maint. Time			

SITE ________ GRC-27 METER CHECKS SET NO. ________

DATE																					
TIME																					
LINE VOLTAGE																					
MOD PLATE																					
PA PLATE																					
DRIVER PLATE																					
AMP PLATE																					
2 DRIVER GRID																					
3 DRIVER GRID																					
PA GRID																					
POWER OUT																					
SWR																					
% MOD																					
FAN MOTORS																					

RELATIVE HUMIDITY AND TEMPERATURE DAILY LOG

LOCATION____________

DATE	0800		1200	1800	2400	DATE	0800		1200	1800	2400
	REL. HUM.	TEMP.	TEMP.	TEMP.	TEMP.		REL. HUM.	TEMP.	TEMP.	TEMP.	TEMP.

APPENDIX III

BREAKDOWN OF PARTS AS A CLASS INTO VARIOUS SUBCLASSES

(As Coded for Machine Tabulation in Section 4.3)

B (BLOWER-MOTOR)

CODE	SPEED	INSULATION
A	500-1999	A
B	500-1999	B
C	500-1999	H
D	500-1999	Other
E	500-1999	Unknown
F	2000-3999	A
G	2000-3999	B
H	2000-3999	H
I	2000-3999	Other
J	2000-3999	Unknown
K	4000-5999	A
L	4000-5999	B
M	4000-5999	H
N	4000-5999	Other
O	4000-5999	Unknown
P	6000-8999	A
Q	6000-8999	B
R	6000-8999	H
S	6000-8999	Other
T	6000-8999	Unknown
U	9000 or more	A
V	9000 or more	B
W	9000 or more	H
X	9000 or more	Other
Y	9000 or more	Unknown
Z	Unclassified	

BZ (SYNCRO)

(Z is to be added on to basic circuit symbol B)

CODE	DESCRIPTION
A	Control Transformer
B	Differential Generator
C	Differential Motor
D	Generator
E	Motor
Z	Unclassified

C (CAPACITOR)

CODE	JAN OR MIL TYPE	MODIFICATION
A	CB	Standard
B	CB	Variation from basic chart
C	CB	Closest to it
D	CC	Standard
E	CC	Variation from basic chart
F	CC	Closest to it
H	CK	Variation from basic chart
I	CK	Closest to it
J	CM	Standard
K	CM	Variation from basic chart
L	CM	Closest to it
M	CN	Standard
N	CN	Variation from basic chart
O	CN	Closest to it
P	CP	Standard
Q	CP	Variation from basic chart
R	CP	Closest to it
S	CV	Standard
T	CV	Variation from basic chart
U	CV	Closest to it
V	Air	Standard
W	Air	Variation from basic chart
X	Air	Closest to it
Z	Unclassified	

CR (CRYSTAL)

CODE	TYPE OF MATERIAL	USE
A	Germanium	Detector
B	Germanium	p-N-p Transistor
C	Germanium	Point contact transistor
D	Germanium	Rectifier
E	Selenium	Detector
F	Selenium	p-N-p Transistor
G	Selenium	Point contact transistor
H	Selenium	Rectifier
I	Silicon	Detector
J	Silicon	p-N-p Transistor
K	Silicon	Point contact transistor
L	Silicon	Rectifier
Z	Unclassified	

E (MISCELLANEOUS)

CODE	DESCRIPTION
A	Air Compressor
B	Adapter
C	Resistor Assembly
D	Capacitor Assembly
E	Terminal
F	Insulator
*	Incandescent Lamp - AC
*	Incandescent Lamp - DC
Z	Unclassified

* In the case of E being either of these, use the code developed for I, and place an I after the E in the circuit symbol.

I (INDICATOR)

CODE	DESCRIPTION
A	Glow Lamp
B	Incandescent - AC
C	Incandescent - DC
Z	Unclassified

J AND P (JACKS, PLUGS)

CODE	TYPE	NUMBER OF ACTIVE CONTACTS
A	AN or MS	1-3
B	AN or MS	4-7
C	AN or MS	8-12
D	AN or MS	13-20
E	AN or MS	21 or more
F	BNC	1
G	BNC	2
H	BNC	3
I	BNC	4
J	BNC	5 or more
K	26 series (Amphenol)	1-8
L	26 " "	9-16
M	26 " "	17-24
N	26 " "	25-32
O	26 " "	33 or more
P	Other - GP	1-3
Q	Other - GP	4-7
R	Other - GP	8-12
S	Other - GP	13-20
T	Other - GP	21 or more
U	Other - RF	1
V	Other - RF	2
W	Other - RF	3
X	Other - RF	4
Y	Other - RF	5 or more
Z	Unclassified	

K (RELAY)

CODE	RELAY CLASS	ACTUATIONS
A	General Purpose	Less than 1 every 10 hr.
B	General Purpose	1 every 10 hr. - 1 per hr.
C	General Purpose	2 - 5 per hour
D	General Purpose	6 - 50 per hour
E	General Purpose	51 - 499 per hour
F	General Purpose	500 per hour or more
G	Power	Less than 1 every 10 hr.
H	Power	1 every 10 hr. - 1 per hr.
I	Power	2 - 5 per hour
J	Power	6 - 50 per hour
K	Power	51 - 499 per hour
L	Power	500 per hour or more
M	Sensitive	Less than 1 every 10 hr.
N	Sensitive	1 every 10 hr. - 1 per hr.
O	Sensitive	2 - 5 per hour
P	Sensitive	6 - 50 per hour
Q	Sensitive	51 - 499 per hour
R	Sensitive	500 per hour or more
S	Thermal	Less than 1 every 10 hr.
T	Thermal	1 every 10 hr. - 1 per hr.
U	Thermal	2 - 5 per hour
V	Thermal	6 - 50 per hour
W	Thermal	51 - 499 per hour
X	Thermal	500 per hour or more
Z	Unclassified	

L (COIL)

CODE	TYPE OF COIL	INSULATION
A	Air Core	A
B	Air Core	B
C	Air Core	H
D	Air Core	Other
E	Air Core	Unknown
F	Air Core	Not important
G	Iron Core	A
H	Iron Core	B
I	Iron Core	H
J	Iron Core	Other
K	Iron Core	Unknown

L (COIL) CONT.

CODE	TYPE OF COIL	INSULATION
P	R.F. Coil, Transformer	A
Q	R.F. Coil, Transformer	B
R	R.F. Coil, Transformer	H
S	R.F. Coil, Transformer	Other
T	R.F. Coil, Transformer	Unknown
U	R.F. Coil, Transformer	Not Important
Z	Unclassified	

R (RESISTOR)

CODE	JAN OR MIL TYPE	MODIFICATION
B	RA	Variation from basic chart
C	RA	Closest to it
D	RB	Standard
E	RB	Variation from basic chart
F	RB	Closest to it
G	RC	Standard
H	RC	Variation from basic chart
I	RC	Closest to it
J	RN	Standard
K	RN	Variation from basic chart
L	RN	Closest to it
N	RP	Variation from basic chart
O	RP	Closest to it
Q	RV	Variation from basic chart
R	RV	Closest to it
S	RW	Standard
T	RW	Variation from basic chart
U	RW	Closest to it
W	RU	Variation from basic chart
X	RU	Closest to it
Z	Unclassified	

S (SWITCH)

CODE	SWITCH TYPE	ACTUATIONS
A	Rotary	Less than 1 per 10 hr.
B	Rotary	1 per 10 hr. - 1 per hr.
C	Rotary	2 - 15 per hour
D	Rotary	16 per hour or more
E	Sensitive, Large	Less than 1 per 10 hr.
F	Sensitive, Large	1 per 10 hr. - 1 per hr.
G	Sensitive, Large	2 - 15 per hour
H	Sensitive, Large	16 per hour or more
I	Sensitive, Small	Less than 1 per 10 hr.
J	Sensitive, Small	1 per 10 hr. - 1 per hr.
K	Sensitive, Small	2 - 15 per hour
L	Sensitive, Small	16 per hour or more
M	Toggle	Less than 1 per 10 hr.
N	Toggle	1 per 10 hr. - 1 per hr.
O	Toggle	2 - 15 per hour
P	Toggle	16 per hour or more
Q	Thermostatic	Less than 1 per 10 hr.
R	Thermostatic	1 per 10 hr. - 1 per hr.
S	Thermostatic	2 - 15 per hour
T	Thermostatic	16 per hour or more
Z	Unclassified	

T (TRANSFORMER)

CODE	TYPE	INSULATION
A	Filament, Audio, Video	A
B	Filament, Audio, Video	B
C	Filament, Audio, Video	H
D	Filament, Audio, Video	Other
E	Filament, Audio, Video	Unknown
F	Power	A
G	Power	B
H	Power	H
I	Power	Other
J	Power	Unknown
K	Pulse	A
L	Pulse	B
M	Pulse	H
N	Pulse	Other
O	Pulse	Unknown

T (TRANSFORMER) CONT.

CODE	TYPE	INSULATION
P	R.F. Coil, Transformer	A
Q	R.F. Coil, Transformer	B
R	R.F. Coil, Transformer	H
S	R.F. Coil, Transformer	Other
T	R.F. Coil, Transformer	Unknown
U	R.F. Coil, Transformer	Not important
Z	Unclassified	

V (TUBE)

MINIATURE

AA	Diode
AB	Dual Diode
AC	Triode
AD	Dual Triode
AE	Pentode-Tetrode
AF	Pentagrid
AG	Thyratron
AJ	Voltage Regulator

OCTAL

BA	Diode
BB	Dual Diode
BC	Triode
BD	Dual Triode
BE	Pentode-Tetrode
BF	Pentagrid
BG	Thyratron
BJ	Voltage Regulator

V (TUBE) CONT.

SUBMINIATURE

CA	Diode
CB	Dual Diode
CC	Triode
CD	Dual Triode
CE	Pentode-Tetrode
CF	Pentagrid
CG	Thyratron
CJ	Voltage Regulator

SPECIAL

DA	Diode
DB	Dual Diode
DC	Triode
DD	Dual Triode
DE	Pentode-Tetrode
DF	Pentagrid
DG	Thyratron
DH	Thyratron, Hydrogen
DI	Dual Pentode
DJ	Voltage Regulator
DK	Neon
DL	Diode-Gas
DM	Dual Diode-Gas
DN	Cathode Ray-Electrostatic
DO	Cathode Ray-Electromagnetic
DP	Phototube-Gas

WAVEGUIDE TUBE

EA	Klystron, receiving
EB	Klystron, power
EC	ATR
ED	TR
EE	PreTR
EF	Magnetron - L Band
EG	Magnetron - S Band
EH	Magnetron - X Band

[illegible]

Unclassified

W (CABLE)

A	R.F. Cable
B	Ordinary Cable
Z	Unclassified

X (TUBE SOCKET)

X as a symbol in present day usage stands for holder or socket. It must always be combined with another symbol to signify what it holds, e.g. XV - tube socket. Therefore, as a general rule we will make the thing it holds the guidepoint and classify it accordingly, e.g.

> X - Tube socket would be changed to
> XV - Tube socket and since it holds a
> 12AT7 in place, it would be coded AD,
> the code number associated with the tube.

Y (CRYSTAL)

CODE	TYPE
A	CR-18/U
B	CR-23/U
C	CR-32/U
Z	Unclassified

(SPECIAL CIRCUITS AND FUN[illegible])

CODE	DESCRIPTION
A	Standard Delay Line
B	Mercury Delay Line
C	Pulse Transformer and Delay Line
D	Lighthouse Tube Amplifier Cavity
E	Power Amplifier Tube Cavity
F	Pulse Forming Network
G	Electrical Noise Suppressor
H	Filter Network
I	Dummy Load
J	Attenuator
K	Lo-power Amplifier Tube Cavity
L	Suppressor, Parasitic
M	Coil, R.F. plate circuit for R.F. stage
N	Oscillator Subassembly
O	Duplexer Network
P	Directional Coupler
Q	Preselector Assembly
Z	Unclassified

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...GOVERNMENT OR OTHER DRA... ...ATIONS OR OTHER DATA ...ANY PURPOSE OTHER THAN IN ...A DEFINITELY RELATED ...PROCUREMENT OPERATION, ...MENT THEREBY INCURS ...NOR ANY OBLIGATION ... ...THE FACT THAT THE ...MAY HAVE FORMULATED, ...WAY SUPPLIED THE ...HOLDER OR ANY OTHER ...OTHERWISE AS IN ANY MANNER ...HOLDER OR ANY OTHER ...PERMISSION TO MANUFACTURE, ...RELATED THERETO.

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